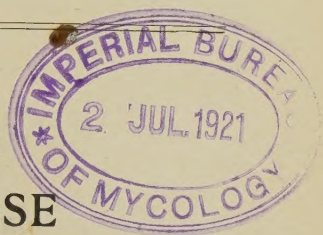


J. Lind,
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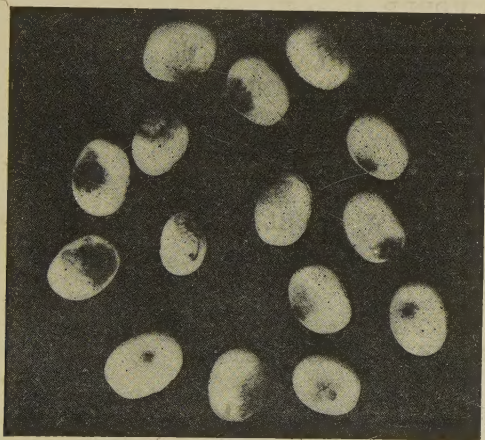
MAY, 1908

BULLETIN 255

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Plant Pathology



BEAN ANTHRACNOSE



By H. H. WHETZEL

DEPARTMENTS OF THE
DEPARTMENT OF PLANT PATHOLOGY

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FIRST REPORT ON THE BEAN ANTHRACNOSE INVESTIGATIONS.

For the past two years the writer has been devoting considerable time to observations and experiments on the anthracnose or pod-spot of beans. The investigation has now progressed far enough to warrant a preliminary report. Certain recommendations usually made for the control of this disease have been found to be worthless or impractical. Others appear to be of doubtful value. At least one new factor in the control of the disease, viz., clean seed obtained by pod selection, has presented itself and gives promise of solving the problem. A summarizing of the results obtained thus far on these points, seems desirable in order that we may determine definite lines of investigation for our future work, and present to the grower the latest and best information which we have on the subject. The beginning of the work on this disease was marked by the publication of Bulletin 239, "Some Diseases of Beans." It was prepared at the close of the first year's observations on the anthracnose, and is, as indicated therein, largely a compilation from what appeared to be the most reliable sources of information. From a careful and exhaustive study of the literature on the subject up to that time, certain methods of controlling the disease were proposed and recommended to the growers. The bulletin was prepared to meet the demand of growers for information on the subject. Since its publication we have endeavored to determine, largely by observation in the field, whether or not the methods there recommended are effective and practicable.

As a result of three years' observation and experience, together with some experiments directed along the lines of some of the recommendations made, it seems necessary to modify the generally accepted conclusion in regard to the control of this disease. On this account I shall briefly review the different methods proposed in Bulletin 239, pointing out certain incorrect or impractical recommendations.

CRITICISM OF BULLETIN 239.

Seed treatment.—Nothing has been done in an experimental way to determine the accuracy of the conclusions recorded on this point, but for two reasons the writer believes them to be correct: first, *that what experiments have been reported along the line of seed treatment, have in general shown that the benefits derived are insignificant, especially when*

there is taken into consideration the loss of seed resulting from such treatment; in the second place, as pointed out in the bulletin under discussion page 206, "*The mycelium of the fungus is imbedded in the bean itself, and any poison that will penetrate sufficiently to kill the fungus will usually kill the seed.*" In other words, the nature of the bean Anthracnose disease is such that treatment with poisons cannot be effective, since they cannot reach the parasite within the tissues of the host without also destroying the host itself. In the case of oat smut, for example, the spore of the parasitic fungus, which causes the disease, is on the outside of the kernel where it may be readily reached by a poisonous solution. On the other hand, in the case of loose smut of wheat we have a condition analogous to the bean anthracnose. Here the fungus enters the young seed, penetrating deeply into the flesh. It has been found that seed treatment with formalin, for example, which is effective for the oat smut, is entirely ineffective in the case of the loose smut of wheat, and for this reason the analogous case of the bean anthracnose may hardly be expected to be exceptional.

Selection of clean seed.—On page 206, it is recommended that all beans should be carefully handpicked in order to remove the diseased seed. Many growers do this regularly in order to obtain a good stand, for by hand-picking they remove wrinkled and broken seed. It has also been believed that we might thus eradicate the anthracnose. Careful germination tests conducted during the winter of 1907, showed beyond doubt that the anthracnose could not be eradicated in this manner. In the case of White Beans, a certain amount of the anthracnose may undoubtedly be gotten rid of in this way, but even here the writer, though using the utmost care to remove every suspicious looking bean, was unable to remove completely the diseased seed, for upon making germination test of the seed thus sorted, as much as 12 per cent. was found to still show the disease. In the case of black or colored beans, sorting to remove anthracnosed seed was entirely ineffective. One grower who had been to considerable expense in hand picking his beans, which were of the Refugee variety, sent samples to the writer both of the clean beans and the culls. Repeated germination tests from these samples, showed that on the average as many diseased seed had gotten into the presumably clean beans, as had been cast out in the culls. In other words, the grower had thrown away a very large per cent. of his seed, and that too at a considerable expense. From these observations the writer is forced to the conclusion that *the hand-picking of beans to eradicate or even partially control the pod-spot is of no value, and is therefore not to be recommended.*

Removal of diseased seedlings.—In preparing the first bulletin on this subject, the writer found that several investigators of this disease had recommended the removal of diseased seedlings. Theoretically this would undoubtedly be effective, but *it is absolutely impracticable* except in short garden rows, and even then, as the writer has since satisfied himself many times, only an expert would be able to do effective work in removing them. Even if it were possible for the ordinary workman to recognize every diseased seedling, it would be an endless and almost impossible task to go over large fields. Their removal, therefore, may be entirely disregarded as a factor in controlling this disease.

Spraying with Bordeaux mixture.—Several investigators have reported remarkable results from spraying with Bordeaux mixture. After three seasons' observations in large bean fields where the most up to date machinery is used, machinery particularly adapted for the bean crop, the writer is forced to the opinion, that spraying with Bordeaux mixture is, to say the very least, unprofitable. It appears to be not only unprofitable, but entirely ineffective in reducing the anthracnose. In bean fields, side by side, one sprayed and the other unsprayed, grown from the same seed on soil almost identical, anthracnose has been equally destructive. On the other hand, experiments conducted by the writer on a few rows of beans in experimental plots, have apparently shown that if thoroughly and properly applied, Bordeaux mixture is effective in controlling the disease. The difficulty in the field, therefore, seems to be that the present machinery does not effectively cover the parts of the bean plant that must be covered with the poison. If the disease is to be controlled, not only the upper surfaces of the leaves, but the stems and pods must be coated with the Bordeaux. We have been unable to find a machine that will do this, after the beans have formed any considerable top. Until a machine is put on the market that will cover the stems and pods at any stage in the growth of the plant, little or no results can be expected from spraying. It is stated in the bulletin that three sprayings will be sufficient. Some growers have sprayed their beans almost weekly throughout the season, but neither they nor the writer could see any material results from the sprayings. At the bottom of page 208, we find the statement that the writer "has shown that one or two thorough sprayings, even if a large percentage of the plants were badly diseased, will insure a clean and profitable crop." He still stands behind that statement, but would point out, that this was on small experimental rows where the work could be carefully done. That it *may* be possible to control the disease by spraying, even under field conditions, the writer will grant. More than that,

it is proposed to conduct during the next few years careful experiments to determine if an effective machine may not yet be found for this purpose. However, the observations of the past two seasons have brought to light certain conditions, which would still have to be overcome, even if an effective arrangement of nozzles were worked out. In the first place, many beans are grown on extremely stony soil. The difficulty of keeping the nozzles in proper position on such soils is best apparent to those who have tried the operation. Another difficulty is that of applying the mixture at the proper time. This is particularly true during seasons of heavy rain. The growing parts of the plant must constantly be kept covered with the mixture. If the soil is soft from heavy rains, it may be impossible to get on the fields with heavy machinery in time to make the application effective. But even if these conditions were finally surmounted, spraying would still remain very expensive on account of the machinery, chemicals, and labor required, and last and not unimportant, spraying of any kind is an exceedingly unpleasant business, *and can be effectively done only by competent persons*. For this reason, if another method of controlling the disease can be found, it should certainly be tested out and presented to the grower.

Cultivating or working beans when wet should be avoided as much as possible. On this point there can be no dispute. The character of the parasite causing the disease, and the practical experience of growers everywhere show that this recommendation is correct.

Susceptibility of varieties.—The writer has nothing to add to the discussion on this point.

NATURE OF THE DISEASE.

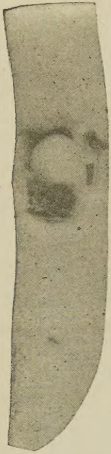
The Bean Anthracnose is known to growers under a number of different names, depending largely upon the locality. Perhaps the most common one applied to this malady is "rust." However, as a matter of fact the disease is not rust at all, though the spots do have a reddish yellow color in their early stages. There is a true rust of beans which is rarely met with in ordinary bean fields. Pod-spot is a name which is frequently applied to the disease, as it appears in the pods. Blight is also commonly used, but incorrectly so, as we have a true bacterial blight of beans, which is not only very common, but frequently quite destructive. The general characters of these three commonest diseases of beans are set forth in bulletin 239, and accompanied with figures, which show clearly their respective characters. This bulletin is still in print and will be sent upon application. Whatever name may be

locally given to the anthracnose, it is still one and the same disease that most bean growers have in mind. The disease is readily recognized by the appearance which it gives to the infected pods, and it is here that the trouble is usually first recognized. Fig. 217 shows the too familiar



FIG. 217.—Anthracnose spots or cankers on the pods. The fungus in these cankers penetrates through the pod into the bean.

appearance of this stage of the disease. The spots or cankers are black with reddish or yellowish margins. Most growers are also familiar with the appearance of the disease on the seed itself, especially on the white beans where it makes rusty red spots of different sizes, sometimes involving nearly the entire seed, though ordinarily only producing a slight discoloration on one side. (Cover.) The disease enters the seed by way of the pod, the fungus penetrating from the outside into the young and tender seed. This is very well shown in Fig. 218. The cankered



pod has been carefully dissected away, showing brown spot on the bean just underneath. When the diseased seeds are planted in the soil, and first come through the ground they are sure to show the small black cankers on the cotyledons or seed leaves (Fig. 219) and a little later on the stems. Fig. 220. Growers seldom recognize the disease on the seedlings as that with which they are familiar on the pods and beans. Many of them have observed the blackened stubs of badly diseased seedlings, and have thought the injury due to insects of some kind. Where badly diseased seed is planted the loss from diseased seedlings is at times quite heavy.

History and economic importance of the disease in this state.—Many growers are inclined to the belief that this is a new disease that became really destructive for the first

time during 1906. As a matter of fact, it has long been known in this State and was very well described and figured by Professor Beach of the Geneva Station in Bulletin 48, published in 1892. At that time the disease was so

severe in the bean-growing regions of the State as to seriously threaten the industry. Like most other fungous diseases the bean anthracnose has its epidemic periods. Such a period reached maximum severity in the season of 1906. For three or four years previous to this time the writer had observed the gradual increase of this disease in the bean fields which he had occasion to visit about the State. The epidemic period for this disease, as well as for many others, follows very closely the periodic variations of weather conditions. It will be recalled that the season of 1906 was a very rainy one, particularly at the time when the beans were making very rapid growth in the spring, and also at the time when the pods were forming. The three or four years preceding this time had been increasingly rainy during the growing period. The gradual increase of the anthracnose thus followed directly the increasing raininess of the seasons.

Of course the explanation of this is, not that the rainy seasons caused the disease, but that they were especially favorable to the spread and development of the fungus (*Colleototrichum lindemuthianum*), which is the real cause. As a natural result of this there was an increasingly large amount of infection carried over in each succeeding bean crop, so that the following season always found a larger number of diseased plants in the bean fields. These two factors contributed largely to the epidemic character of the malady which became so marked in 1906. Quite a large number of germination tests were made during the winter of 1907 on the bean seed of the 1906 crop from various parts of this and adjoining states. This seed showed a general average of more than 20 per cent. of anthracnose in it, many samples showing a very much larger proportion than that, while a very few showed as little as 4 per cent. There was every reason to believe that this seed, if planted during the season of 1907 would result in another epidemic of the pod spot. Just the reverse proved to be the case, but this was due, not to the want of the disease in the fields, as I shall point out, but chiefly to one fact, that the season was exceptionally dry, in particular at those times when the fungus was most in need of rain for its development and distribution, namely, during the early stages of germination and growth of the seedlings, and later at the time when the pods were being formed and developed. As a matter of fact, the disease was very common in practically all of the bean fields in the State. Careful examination of a number of fields showed as high as 90 per cent. of the pods spotted with the anthracnose, but owing to the dry weather these spots never developed sufficiently to penetrate the pods to any extent, and thus materially affect the beans within. The bean seed of the crop of 1907, therefore, has been found to be remarkably free from the pod-spot; although in almost any sample a bean will be found here and there that is distinctly spotted. On account of the inadequate greenhouse accommodations during the past winter, we were unable to test out thoroughly samples of the 1907 seed, but

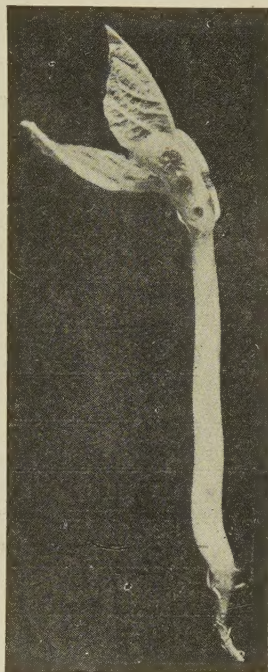


FIG. 219.—Seedling, just up, showing the disease on the cotyledons.

from the examinations that the writer has made of this seed, he is inclined to believe that the seed planted this year will be relatively free from the disease, though not sufficiently so to prevent serious loss, should weather conditions be particularly favorable. The practice of



FIG. 220.—Showing anthracnose spots on stem and leaves of bean just before blossoming time. It is from these spots that spores are distributed to the pods.

purchasing seed from distant seedmen, or from growers in other parts of this State or other States, will be of little or no value in getting rid of the anthracnose, as we have found the disease to be very generally distributed throughout the eastern and central United States, and is not unknown, by any means in the West.

Cause of the disease.

—As indicated above the disease is caused by the fungus, *Collectotrichum lindemuthianum* the main features of the life history of which are well known and have been carefully detailed in bulletin 239.

Fig. 221, which is reprinted from bulletin 239, shows the general

structure of the parasite and the relation which it bears to the spotted seed within. It may be well to repeat here, what has already appeared in bulletin 239 on this phase of the subject. "The disease may and usually does occur, however, on all parts of the plant except the roots. (Fig. 220). It is caused by a fungus known to botanists as *Collectotrichum lindemuthianum* which lives as a parasite in the tissues of the bean. This fungus is a plant, as much a plant as the bean on

which it lives. It has a thread-like mycelium that grows into the tissue of the bean to obtain food for its growth and development and it produces *spores* that serve the purpose of seeds by which it spreads to healthy beans and so reproduces itself. In fighting the anthracnose fungus, we are fighting a parasitic weed, in its habits not greatly unlike the dodder which often destroys alfalfa."

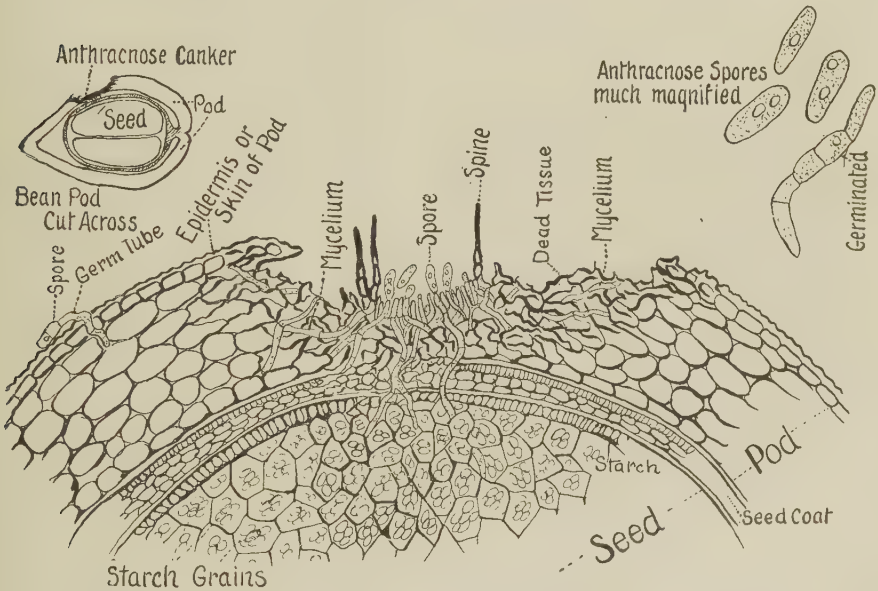


FIG. 221.—Showing the relation of the anthracnose fungus to the tissues of the bean. To the left above is a diagram of a section across a bean pod through an anthracnose canker. The large drawing below is a much enlarged view of a portion of this same section. It is largely diagrammatic. It shows how the mycelial threads of the fungus may penetrate the seed coat and enter the starchy tissue of the seed, there to remain dormant until the following season. On the left of the large drawing is shown a spore germinating and penetrating the epidermis. This germ tube branches, spreads through the tissues of the pod, and so gives rise to a new spot or canker. To the right above is shown a magnified view of some of the spores of the anthracnose fungus. One has germinated. (Original.)

"The fungus itself is too minute to be seen by the unaided eye. This makes an understanding of its nature and ways of life rather difficult, but the picture of the parasite as shown in Fig. 221 will help to make clear the discussion of the disease. Study the picture carefully before reading the following account."

"It is from the attack of the disease on the pods that the most direct and apparent damage to the crop results. During the time of blossom-

ing and previous, the fungus has been spreading and becoming established on the stems and leaves, and it now attacks the young and succulent pods. With their tender growing tissue full of water and food materials, these pods offer the best conditions for the growth and development of the parasite. Spores from the spots on the leaves and stems fall on the pods, where, in the presence of moisture and the high summer temperature, they germinate, forming a little sprout or germ-tube, which penetrates the tender skin of the pod (Fig. 221) and, branching in the juicy tissues,

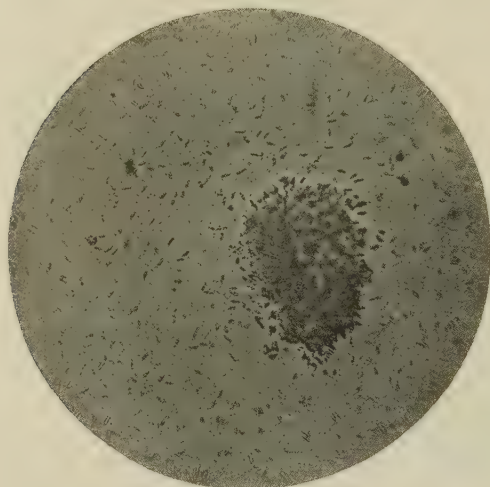


FIG. 222.—Spore of the anthracnose fungus taken on the point of a needle and placed in a drop of water. Magnified about 55 times. The large blur is a mass of the spores from which others have become detached and scattered about in the water.

gives rise to an anthracnose canker. These first appear as little brown or rusty spots which enlarge and darken until nearly or quite black. The dead tissue dries and settles, causing a little pit or sunken place in the pod. In the center of the spot the spores of the fungus are now produced in great abundance. They ooze out and pile up, forming little pink masses easily seen with the naked eye (see Figure 217). These masses of spores are held together by a kind of glue or mucilage which, when dry, sticks them tightly to the spot. When a drop of rain or dew falls on the spot the mucilage is at once dissolved,

and the spores are set free in the water. At this time any disturbance of the bean plants will scatter these spores in the flying drops of water. In this way they reach healthy plants near by. This explains why beans should not be cultivated or handled in the early morning while the dew is still on them or directly after a shower. The spores of the anthracnose fungus are scattered only when they are wet. This will also explain why a warm rainy season is so favorable to the development of the fungus. The spores require moisture in which to be distributed and in which to germinate. A relatively high temperature is also most favorable to the disease. The spores are produced in unlimited numbers in the spots on the pod. Fig. 222 shows the spores

taken on the point of a pin and placed in a drop of water. Only one of these tiny spores is necessary to start a spot. Under favorable conditions these spores spread from pod to pod until practically every bean in a large field may be affected."

CONTROL OF THE DISEASE.

In considering the methods of combatting this disease three or four possible means are presented. First, seed treatment; Second, spraying; Third, the planting of clean seed; Fourth, selection and breeding of resistant or immune varieties.

Seed treatment.—As pointed out above this is of doubtful value, and cannot be recommended, at least not from investigations yet made. If some method of eradicating the disease by treating the seed could be worked out, it would certainly be the most acceptable means of getting rid of so troublesome a fungus. At present, however, the grower cannot afford to spend time and money along this line. It is a problem for the experimenter alone.

Spraying.—This also has been quite fully discussed in the criticism on bulletin 239, and need receive no further consideration here.

Clean seed. Clean seed will grow clean beans.—It is on this proposition that most of the work of our future investigations on this disease will be based. When the writer found that neither the sorting of the seed, nor the spraying of the fields proved effective in practice, he turned his attention to the matter of clean seed. From a very careful study of the fungus that caused the disease, and from observations which he had made in the field, it seemed pretty conclusive that the fungus is carried over from one season to the next, largely, if not entirely in the seed. If then, some method can be found by which perfectly clean seed can be obtained, the problem will be solved. Several experiences have pointed to the conclusion that this would work out in practice. A variety of Black Wax beans were brought by the writer from Indiana in the spring of 1904, and planted in a garden where no beans had been grown, at least for many years. These beans gave a crop perfectly free from the anthracnose and this was more remarkable, since practically all of the beans whether of this or other varieties, grown in neighboring gardens were badly spotted that season. Seed saved from this crop was planted the following season, 1905, in a garden where, the previous season, beans had been badly affected with the pod spot. More than that, they were planted in almost the identical place where the diseased beans had been grown in 1904. Again, they gave a crop perfectly free from the anthracnose, while as before the same variety

grown from seed purchased in the city market gave a diseased crop. The two gardens in which these crops of beans were grown were side by side, separated only by a woven wire fence, the ends of the rows of the beans in the two gardens being not more than 20 feet apart. During the winter of 1905-06, the seed saved from this crop was almost entirely destroyed by weevils, so that for the planting of 1906 there was only a very small quantity of seed, sufficient to plant only a part of a row across the garden. Seed of the same variety, with which to complete the planting, was purchased in the city market, one long row being completed across the garden. Shortly after the beans were up the disease became quite virulent in the plants grown from the purchased seed, while none was to be found in that grown from selected seed of the previous season. All of the plants were thoroughly sprayed once, but the disease had at that time made such progress that it was not controlled, and a gradual spreading of the disease was observed in the row on adjoining plants from clean seed, so that by the time the crop was ready to harvest, only a few of the plants from the clean seed showed pods entirely free from anthracnose. This clearly indicated that the absence of the disease the two preceding years had not been due to varietal resistance. It could be explained only on the basis that there had been no disease in the seed. It further indicated that the disease was not readily carried from one garden to another, else the crop of 1905 should certainly have been diseased. During the winter of 1905-06 a small amount of this seed was sent to a lady near Ithaca, who had been unable to grow Black Wax beans for a number of years, that were free from the pod-spot. She reported a perfectly clean crop in 1906 and saved seed for the following season. At the end of the season, 1907, she again reported a crop entirely free from the spot. It should be pointed out here, that the clean crops of 1906 came in a year when the bean anthracnose was particularly destructive. During the season of 1907, the writer did not plant any seed from the crop of 1906, as what little he succeeded in saving from the uninfected plants, was totally destroyed by weevils during the winter. Fortunately the lady to whom he sent the seed in 1905, sent him during the winter of 1907 a small quantity of this seed, which is presumably free from the anthracnose. This will be planted in 1908, and the writer has every reason to believe that it will give a clean crop.

During the winter of 1906-07, communication was received from a gentleman, in the western part of the United States, who grows beans to a limited extent on irrigated lands. The gentleman declared that he was able to plant diseased seed, received from any of the North East-

ern States, on his irrigated land, and grow a crop perfectly free from the parasite. He accompanied his statement with about a quart of Wardell's Kidney Wax beans, which he had grown on his irrigated lands during the season of 1906. Careful germination tests were made of this seed and no evidence of the anthracnose was to be discovered. The seed was planted during the season of 1907 on an isolated plot of land on the University Farm. At the same time on another plot of land about a quarter of a mile distant was planted seed of the Davis White Wax and Refugee Green Pod, both of which showed by germination test, a large percentage of diseased seed. The Wardell Kidney Wax from the irrigated lands gave a crop entirely free from the anthracnose except for one plant. This plant was at the end of the patch, along which ran a foot path leading directly from a house across the road into the University farm opposite. As there was a garden with diseased beans at the house across the way, it seemed very probable that the infection was carried in by some person passing through this diseased patch and along this pathway. All of the plants in the immediate neighborhood of the infected one were carefully examined, but absolutely no trace of the disease was to be found on any of them. This plant was removed and destroyed. The diseased seed planted in the plot a quarter of a mile away gave a crop that was very generally affected with the anthracnose, and this bear in mind, during the season of 1907, when weather conditions were very unfavorable to the development of the disease. These observations and experiences convince the writer that here is the most promising suggestion for a practical and effective method of controlling the disease. It seems evident, first, that the disease is carried over entirely in the seed; second, that the disease is not ordinarily carried for any considerable distance by natural agents, such as rain, wind, etc.; third, that if perfectly clean seed is planted and ordinary precaution taken to prevent the introduction of the disease on tools, or by workmen, a perfectly clean crop can be produced, even in seasons the most favorable to the development of the fungus.

Methods of obtaining clean seed.—It is first necessary to work out a satisfactory method of obtaining clean seed of the varieties particularly desired in any locality. As has been clearly shown, hand sorting of the seed, after it is has been thrashed from the pods, is a failure, so far as eradicating the anthracnose is concerned. Even if a large percentage of the disease might be eliminated in this way, it would still be ineffective, since in seasons favorable to the disease, a very small percentage of affected seed might be sufficient to destroy or seriously injure the crop.

Considering the manner in which the fungus finds its way into the seed, it seems evident that *if no spots are to be found on the pods, none of the seed within will be diseased*. That is to say, healthy pods contain healthy seed. It is just possible that we may have one exception to this, though, so far as the writer has been able to find there is no positive evidence in favor of such an exception, namely, that infection of the seed may take place by way of the blossom, without any evidence of such infection on the pod or in fact in the seed itself at maturity. Blossom infection is known to take place in a number of fungous diseases, but the nature of this disease is such that, that hardly seems probable. It has been pointed out by some that the sudden and destructive appearance of the disease in pods at a certain stage in their development, seems to indicate that something of this sort takes place. It is a common observation also, that pods picked in the evening apparently entirely free from the disease will sometimes be found the following morning to be very badly spotted, and shippers of garden truck have often suffered serious losses from the development of this disease in snap beans during the short time required for the transportation from fields to market. Nevertheless, while the writer has seen several cases of this nature, he has never been satisfied that the infection was not due to the ordinary inoculation of the pods by spores from occasional diseased pods among the healthy; the rapid development of the disease in such cases being due ordinarily to favorable conditions of temperature and moisture. Surprisingly enough in the cases of this kind of which the writer has known, a relatively low temperature, particularly a sudden drop in the temperature seems to have been the controlling factor. If then, the principle laid down, that healthy pods contain healthy seeds, holds true, it seems that we have a fairly easy means of obtaining clean seed. During the season of 1907 the writer undertook the selection of clean pods of a number of varieties of beans in order to determine whether it would be practical and effective. On account of the large amount of work on hand during the autumn, only a very small amount of seed of a few varieties was thus obtained. Perhaps, enough to plant half an acre of a total of five or six varieties. Some germination tests of the seed thus obtained were made during the winter of 1907-08, and in no case was any anthracnose discovered. This seed has been planted during the season of 1908, to see if it will give a perfectly healthy crop. However, the conditions under which the seed of this year were collected were far from favorable. In the first place, the selection and sorting of the seed had to be left largely to students or inexperienced assistants; in the second place, the season was so far advanced when the selection

of pods was made when most of them were over-ripe and in some cases covered with sand and dirt from heavy rains. The selections should have been made at the time when the pods began to shrivel but before they had become perfectly dry. It was found that hand picking and sorting of these pods was not nearly so difficult a problem as one might expect. The anthracnose cankers are so large and readily recognized, that with a little coaching any person of ordinary intelligence and care may be depended upon to sort out the healthy pods. It was necessary however to examine both sides of every pod.

Our experience with seed grown on irrigated lands is too limited to warrant us in coming to any definite conclusions in regard to it. The philosophy of the matter is that, "since there is no moisture in the air, (as no rain falls at the particular place where this crop is grown) the spores of the fungus cannot be distributed," for as pointed out on page 440, the spores remain glued to the spot on which they are developed until dissolved in a drop of rain or dew. We would naturally infer therefore, that where no rain or dew falls upon the parts of the plants above ground, spores would never find the necessary means for distribution. It is not safe, however, to conclude from the limited experience of the writer that seed from all irrigated lands will be found to be free from the disease. However, such sources are worth consideration, and the writer proposes to again this year plant the clean seed obtained from last year's crop of Wardell Kidney Wax, and has already received seed from the same seedman of two varieties of beans of the crop of 1907. These will also be planted and tested out in the same way. The following extract from a letter from Dr. W. A. Orton of the Bureau of Plant Industry, U. S. Department of Agriculture, may be of interest in this connection.

"In regard to the possibility of bringing seed beans from irrigated regions, I would say that during my summer trips I had several opportunities of observing conditions in irrigated districts, and for the first time. I am somewhat surprised to find how prevalent fungous diseases may become in irrigated fields. In a number of instances I found peronosporas, anthracnoses, and similar fungi, prevalent in irrigated fields, where the operations of watering were carried on in such a way as to create a moisture laden atmosphere around the plants, although the general conditions in the locality were, of course, extremely dry. I did not happen upon any bean fields on irrigated lands, but I do not doubt that such fields might be free from anthracnose, as you have found in your experience. I do doubt very much, however, whether it would be safe to rely upon seed from irrigated fields. The Pacific Coast points which I mentioned, are peculiar in that beans are regularly grown from

planting to harvest without a drop of rainfall or irrigation water. Conditions in the West are however extremely variable and each locality must be studied by itself for I found localities like this just mentioned, which were, nevertheless, subject to occasional outbreaks of fungous diseases because they were exposed to continued heavy fogs from the Pacific. This makes an additional reason why general statements in regard to the source of seed would not be reliable."

RESISTANT OR IMMUNE VARIETIES.

Very little work, so far as the writer has been able to discover, has been done along this line, and as pointed out in the criticism on bulletin 239, nothing can be added at the present time to this phase of the subject, It is proposed during the season of 1908 to make a test of as many varieties of beans as can be gotten together to determine what ones may be found more or less resistant to this disease, and perhaps later to carry on in connection with the Plant Breeding Department, some work in breeding resistant varieties. Little immediate relief, however, can be promised from results of such work, since even if resistant varieties are obtained, there will probably be no satisfactory types that can at once be substituted for varieties now generally recognized as most favorable for certain purposes. There would probably be required at best, years of selection to bring them to a condition where they would be of general value.

PLANS OF FUTURE WORK.

A plan of the future work on this problem, may not be out of place in concluding this outline. Briefly, the lines along which the work on this problem are to be prosecuted are as follows: In general the plan comprises, first experiments on the University Farm, carried on under the careful and constant observation of the writer and an assistant, who will be chiefly concerned with this problem for the next three years; second, with cooperative growers about the State, to test in the field the results obtained in an experimental way here at the Station. The chief problems to be solved are:

First, to test the effectiveness of clean pod selection as a means of obtaining clean seed and to demonstrate whether such seed will under all weather conditions grow a clean crop, without spraying or any other treatment for the disease.

Second, to devise and test out a practical method of obtaining sufficient clean seed for planting the crop each year. The latter will be largely cooperative work with the grower.

Third, to determine whether the fungus is carried over winter in the soil, or on tops, pods, etc., and thus to find out whether it will be safe

to follow beans with beans year after year, as is sometimes deemed advisable by growers of snap beans.

Fourth, to determine whether the seed within the pod may be infected by the parasite without showing any external evidence on the pod.

Fifth, to determine whether seed grown on irrigated lands in regions where there is no rain fall, will be found to be constantly free from the disease.

Sixth, to determine the value of spraying in large field operations and to test out the effectiveness of various types of machines devised for this purpose.

Seventh, to determine whether closely related species or strains of the anthracnose fungi occurring on other common hosts, such as apple, grape, watermelon, etc., will cause the disease in beans, and vice versa.

Eighth, to develop strains of resistant or immune varieties by means of selection or hybridization.

Ninth, to determine the value of various methods of seed treatment.

It is the purpose of the Plant Pathologist at this station to make the investigation of this disease of beans, one of the chief lines of work for the next three or more years, until the problem is finally and satisfactorily solved. To this end Mr. M. F. Barrus, recently appointed assistant in this Department has been detailed to devote a large part of his time to the problem and it is expected that the matter will be thoroughly thrashed out before it is dropped.

The results and recommendations presented in this bulletin are based on experiments and observations covering a relatively short period of time. More extensive experiments covering a period of years will be necessary before definite conclusions can be reached on all the points herein discussed. The writer shall not hesitate to abandon any of the recommendations or suggestions presented if they prove incorrect or impractical. This is simply a record of progress, to clear the ground for the next step in the solution of this problem. So important is it to the grower that he should have early advantage of every possible way of combatting these pests so destructive to his crops, that the writer at this time presents what conclusions and suggestions he has even at the risk of having later to modify or withdraw them. Correspondence on this subject is earnestly requested. It is hoped that considerable seed for cooperative experiments with growers may be obtained this season. We shall be glad to outline plans and give what assistance we can to any one who may desire to obtain clean seed for next year's planting. Address all communications to Department of Plant Pathology, New York State College of Agriculture, Ithaca, N. Y.

H. H. WHETZEL.

CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION

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RESIDENTS OF NEW YORK STATE WHO MAY DESIRE THEM.

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121 Suggestions for planting Shrubby.
129 How to conduct Field Experiments with
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134 Strawberries under Glass.
135 Forage Crops.
136 Chrysanthemums.
137 Agricultural Extension Work, Sketch of its
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139 Third Report upon Japanese Plums.
140 Second Report upon Potato Culture.
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